Salinity Gradient Solar Ponds for Truscott Brine Lake:

Red River Basin Advisory Committee Meeting

02 May 2017

Overview

1. Current renewable sources are non-dispatchable, requiring complex storage solutions and/or peaking plants to meet power demand
2. Good Earth Mechanics (GEM) is commercializing Salinity Gradient Solar Pond (SGSP) technology to address this shortfall
   a. Fully-dispatchable solar thermal energy
   b. Able to store energy for weeks, months
   c. Cost-effective, robust/distributed solution
   d. Highly beneficial synergies (e.g., salt remediation, waste disposal)
3. Abstract of the talk:

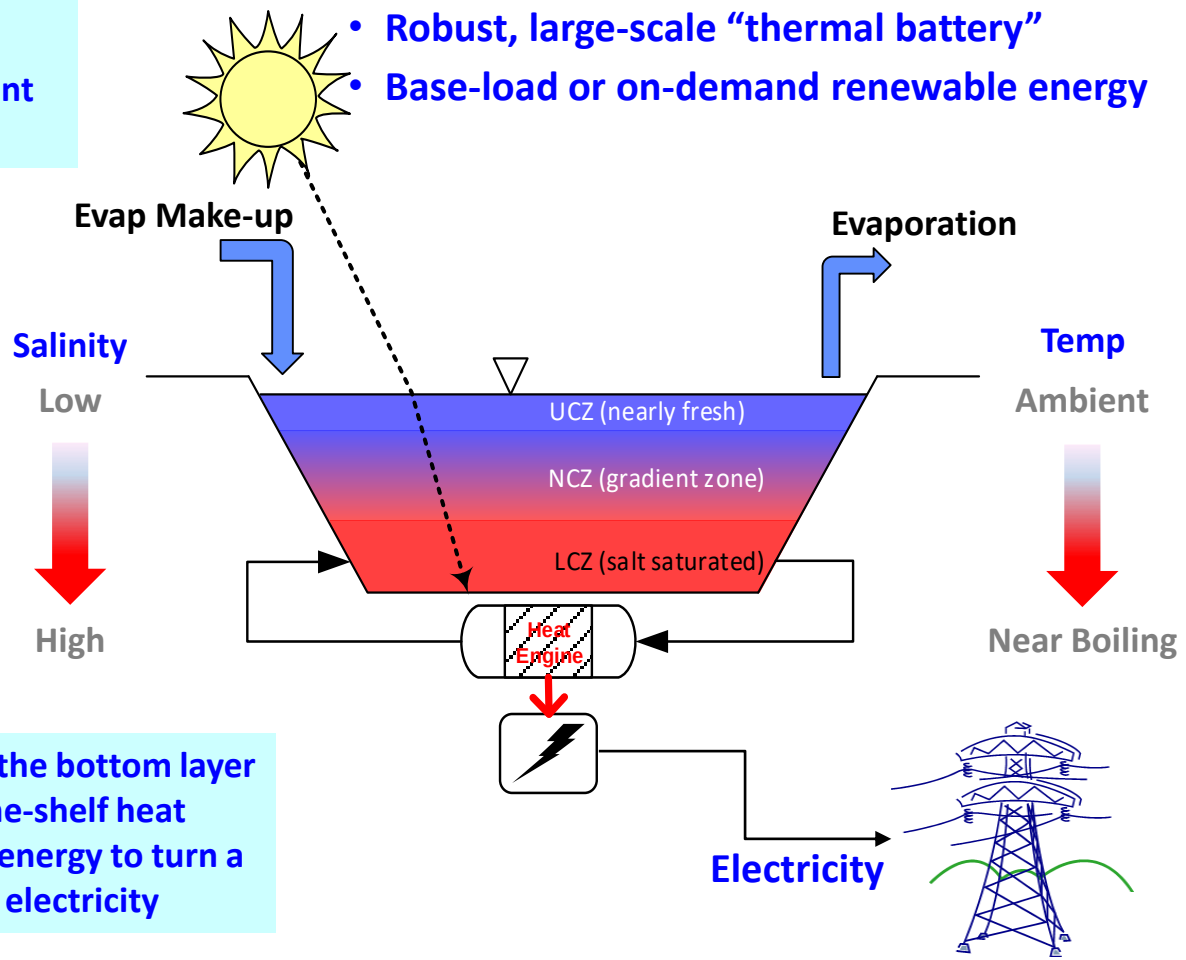
GEM will discuss the SGSP technology, commercialization, and the synergistic benefits of the GEM SGSP applications/projects. The talk will focus on GEM's lead-off project at the U.S. Army Corps of Engineers Truscott Brine Lake and how that project will lead off a wider SGSP development for Texas and elsewhere.

Salinity Gradient Solar Ponds: Naturally Discovered Phenomena

Engineered to Maximize Heat Collection & Storage

Solar energy is absorbed at the pond bottom, heating the adjacent fluid, which is prevented from buoying to the surface and releasing the heat to the ambient due to density stratification

- Collector / storage / delivery all in one
- Robust, large-scale "thermal battery"
- Base-load or on-demand renewable energy



UCZ Upper Convective Zone
NCZ Non-Convective Zone
LCZ Lower Convective Zone

The near-boiling hot brine of the bottom layer is circulated through an off-the-shelf heat engine that uses the thermal energy to turn a turbine-generator to produce electricity

The GEM Salinity Gradient Solar Pond Team:
World Recognized SGSP Leadership

George Nitschke
President & Founder

Peter Gross
Business Development

Dennis Duke
Field Operations

Huanmin Lu
Chief SGSP Scientist

John Walton
SGSP Environmental

Andrew Swift
SGSP & Wind Energy

Herbert Hein, Jr.
SGSP Project Mngmnt

- **16+ years SGSP development at the *University of Texas El Paso (UTEP)***
- **Engineering data & models**
- **Proprietary practices & processes**
- **Patent pending methods & components**
- **Key vendor relationships**
- **Evaluated by NREL Commercialization Assistance Program – favorable review**

Summary paper of Team's SGSP UTEP work:
http://www.goodearthmechanics.com/pdfs/JSEE%20Paper%20Lu%20SP.pdf

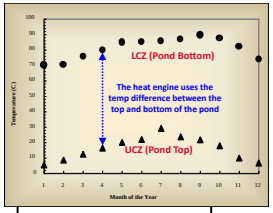
SGSP Development Timeline

GEM SGSP Commercialization Path

GEM SGSP Team members conduct UTEP SGSP R&D – prove tech, develop data

GEM first commercial SGSP systems (planned)

Dr. Lu began SGSP research in Beijing



Nitschke dissertation

GEM formed to commercialize SGSP

Recruited to Ohio St. & UTEP in 1988-1989

GPGT & SGSP Patents

1975 | 1985 | 1995 | 2005 | 2015

Naturally occurring SGSP systems discovered

Commercial SGSP at Dead Sea, Israel

Oil prices average <$20/bbl killing renewable market

Enhanced Geothermal Systems drives low-temp ORC development

Majority of non-GEM SGSP interest and R&D work
Engineer natural SGSP phenomenon for energy production

Sustained market focus on renewable energy systems

GEM's approach to commercialize SGSP technology received a favorable review by NREL (Sept. 2014)

Comparison With Other Renewables

Firm, Dispatchable, Clean Generation Capacity

	Wind	Photovoltaic	Concentrating Systems	SGSP [4]
Footprint kWh/yr/acre	**34,000 [1]**	**152,000 [2]**	**248,000 [3]**	**110,000 (current) 132,000 (future)**
MWh/yr per MW base-plate rating	**3070 (35% capacity factor)**	**1750 (20% capacity factor)**	**2190 (25% capacity factor)**	**7500 (current) 9000 (future) (95% duty cycle) [5]**
Dispatchable?	**No**	**No**	**No**	**Yes [6]**

[1] Example: Navitas Energy; 87 1.5-MW turbines on 10,000 acres; 13 kW (peak)/acre; at 30% capacity factor, avg 3.9 kW/acre; note that "fetch acreage" for wind power is still available for other uses, e.g., cattle, farming

[2] Example: Nellis Solar Pwr Plant , 25E06 kWh/y, 140 acres (178,571 kWh/y/acre) 85% adjust f/ Corpus Christi, 20% capacity factor

[3] Example: 500 MW (peak, Mojave) In-Development Solar 1; 4500 acres at 30% capacity factor w/ 85% adjust for Corpus Christi ***NOTE***: This site has underperformed and is currently in receivership

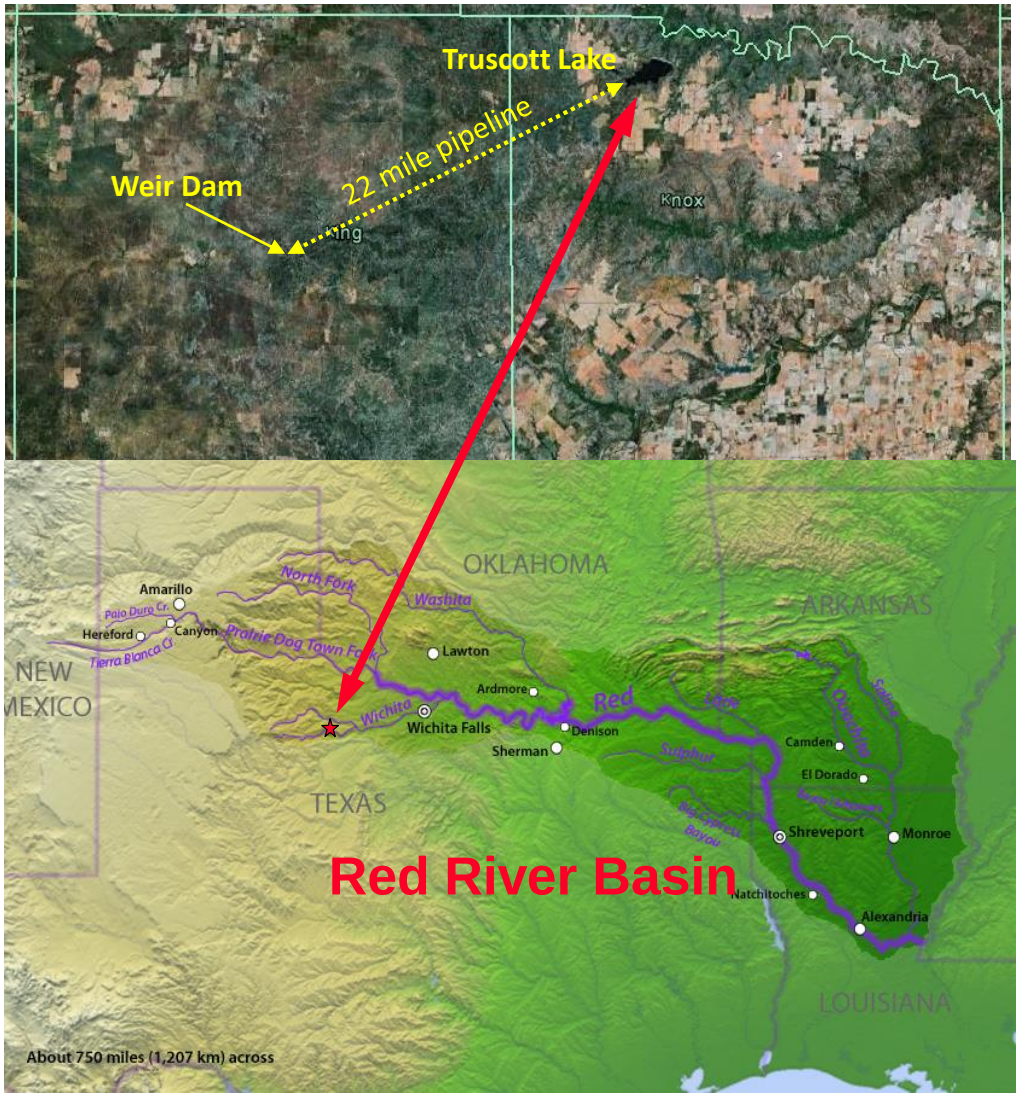
[4] GEM estimate for SGSP in Texas at 20 kWe/acre using low-temp ORC with 0.95 duty cycle (base-load)

[5] In base-load configuration, the equivalent SGSP CF=1.0; the stated value includes parasitic loads and scheduled maintenance

[6] SGSPs are a collector, storage, and delivery system providing fully dispatchable power; other methods have storage costs & inefficiencies

USACE Red River Chloride Control

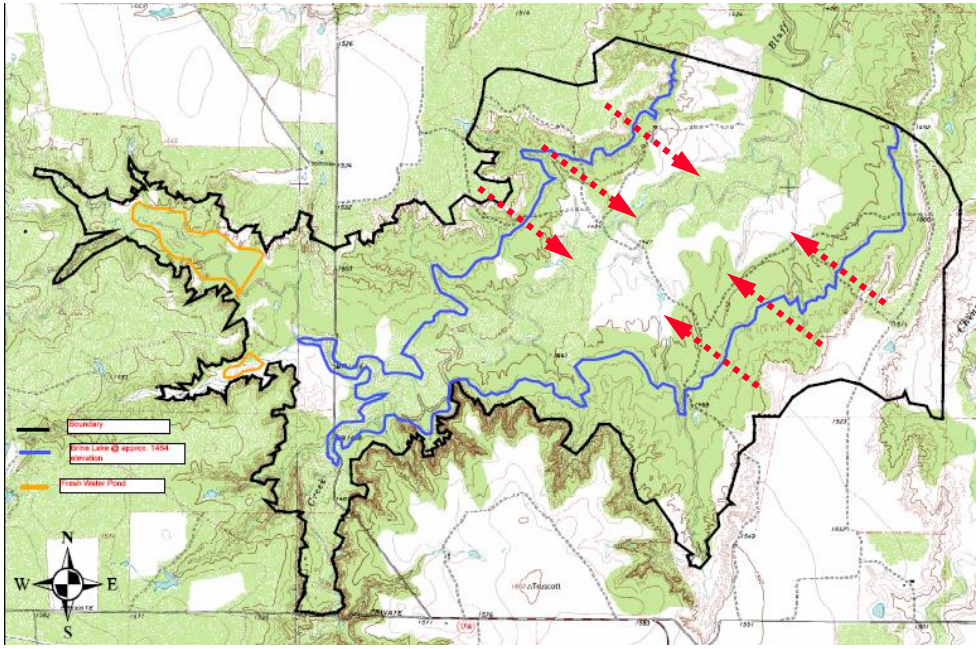
Truscott Lake Salt Impoundment

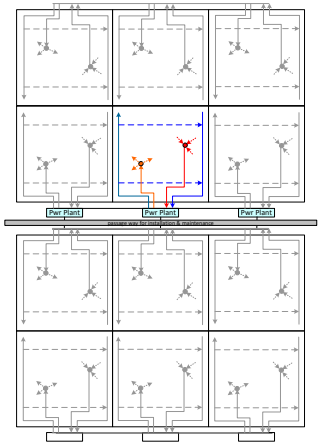


- To reduce chlorides in regional water, the U.S. Army Corps of Engineers (USACE) collects saline river flow and pumps it to the Truscott Lake for impoundment
- The system has been flowing an average of 200 tons/day dissolved salt to the reservoir since 1986 to reduce salinity in Lake Kemp (water for Wichita Falls and Sheppard AFB)
- USACE has determined the Truscott dam will need a repair to mitigate diminishing freeboard
- *Using the salt and lake bed for SGSP systems will negate the need to repair the dam while enabling an increased rate of salt impoundment*

GEM Proposed SGSP Initiative

Power Purchase Agreement Starts Project





- **Modular extensible**
- **Landscape conformable**
- **Tier-step to follow topo**

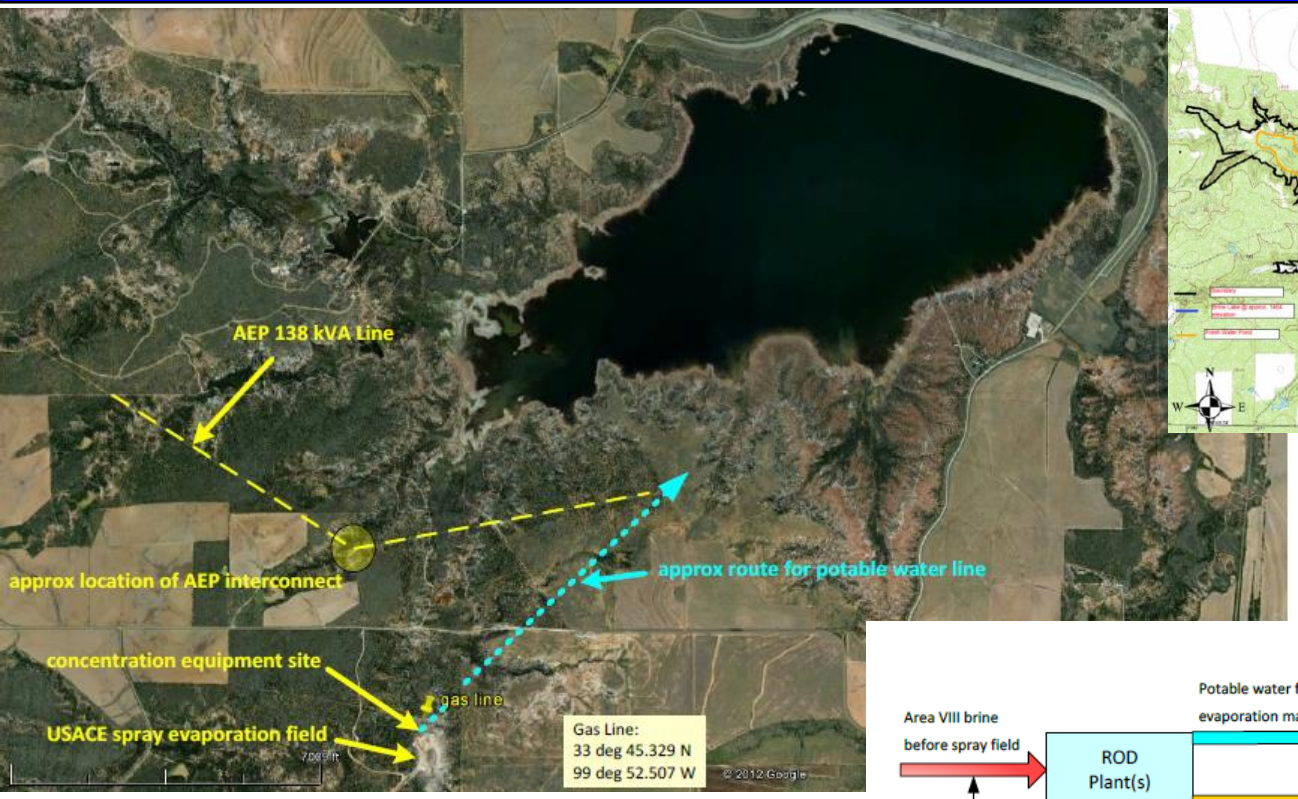
- Using the salt brine currently impounded in Truscott Lake, build ~15 MW solar ponds
- Tie-in to local transmission line and sell power to the ERCOT system (e.g., ancillary power)
- Install the solar ponds within the lake bed area as the lake brine is used for solar pond construction
- Continue/increase salt impoundment and building solar ponds; the Truscott site is large enough for 50 MW SGSP's

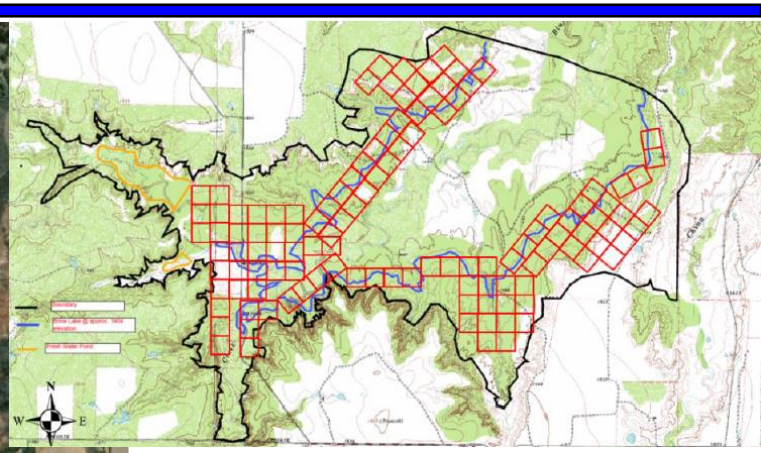
Commercial solution for regional chloride control

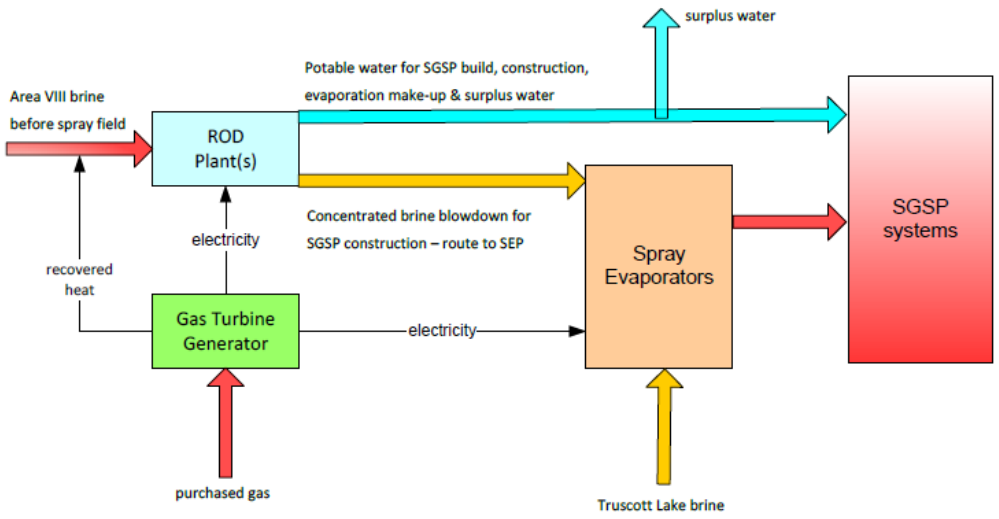
See brief: http://www.goodearthmechanics.com/pdfs/GEM%20to%20Shreveport%20RRVA%20Mtg%2021%20Feb%202013%20-3.pdf

GEM's Approach for Using Lake for SGSP

Concentrate Lake Brine with Surplus Water







Overall Truscott SGSP Plan

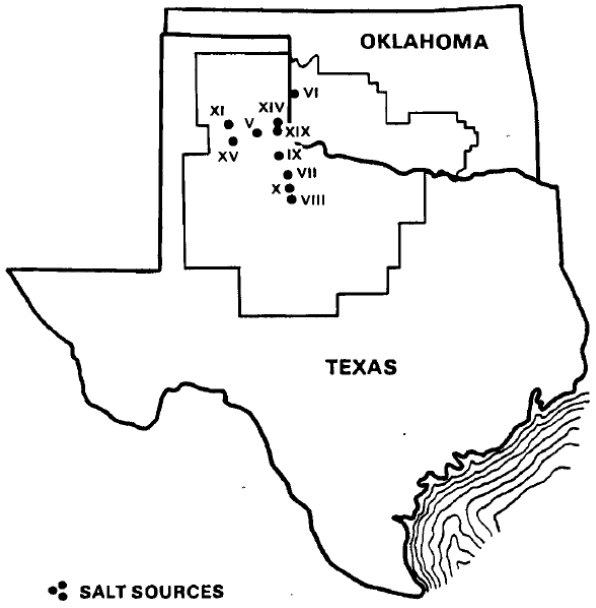
Phase	Time	Power (baseload)	Key Points	Remarks
1	2017	250kW – 15+ MW	• Collaboration between GEM, RRA, USACE • Establish Truscott SGSP design for phased build-out	• Verify GEM SGSP module • Verify Truscott concentration • Verify ITC value and credits
	2018-20+		• Convert reservoir salt to SGSP • Semi-linerless SGSP systems • Shape/contour to reservoir topo	• Nominal rate of 5 MW/yr • Sell power (via ERCOT)
2	in parallel with Ph1	1 MW/yr	• Complete salt collection areas VII, X • Build out SGSP within reservoir area • Phase 1 not dependent on Phase 2	• Pending Congressional funding to the USACE • Manage Lake Kemp salinity below desal threshold
3	Yrs 3+	24+ MW/yr	• Install brine extraction wells • Keep salt from entering rivers • Build out on lake/surrounding land	• Pending approvals, including the responsible environmental authorities

Phase 3: Regional Chloride Control

Region-Wide Deployment in TX & OK

GEM's deployment of SGSP systems will provide a commercial solution to the region's salt-contamination problem (Brazos & Red River Basins)

- USACE estimates 1.6M tons/year natural salt flows to the Red River Basin
- Studies estimate 2.4M tons/year natural salt flows to the Brazos River Basin
- GEM SGSP systems require approximately 170,000 tons/MW to build



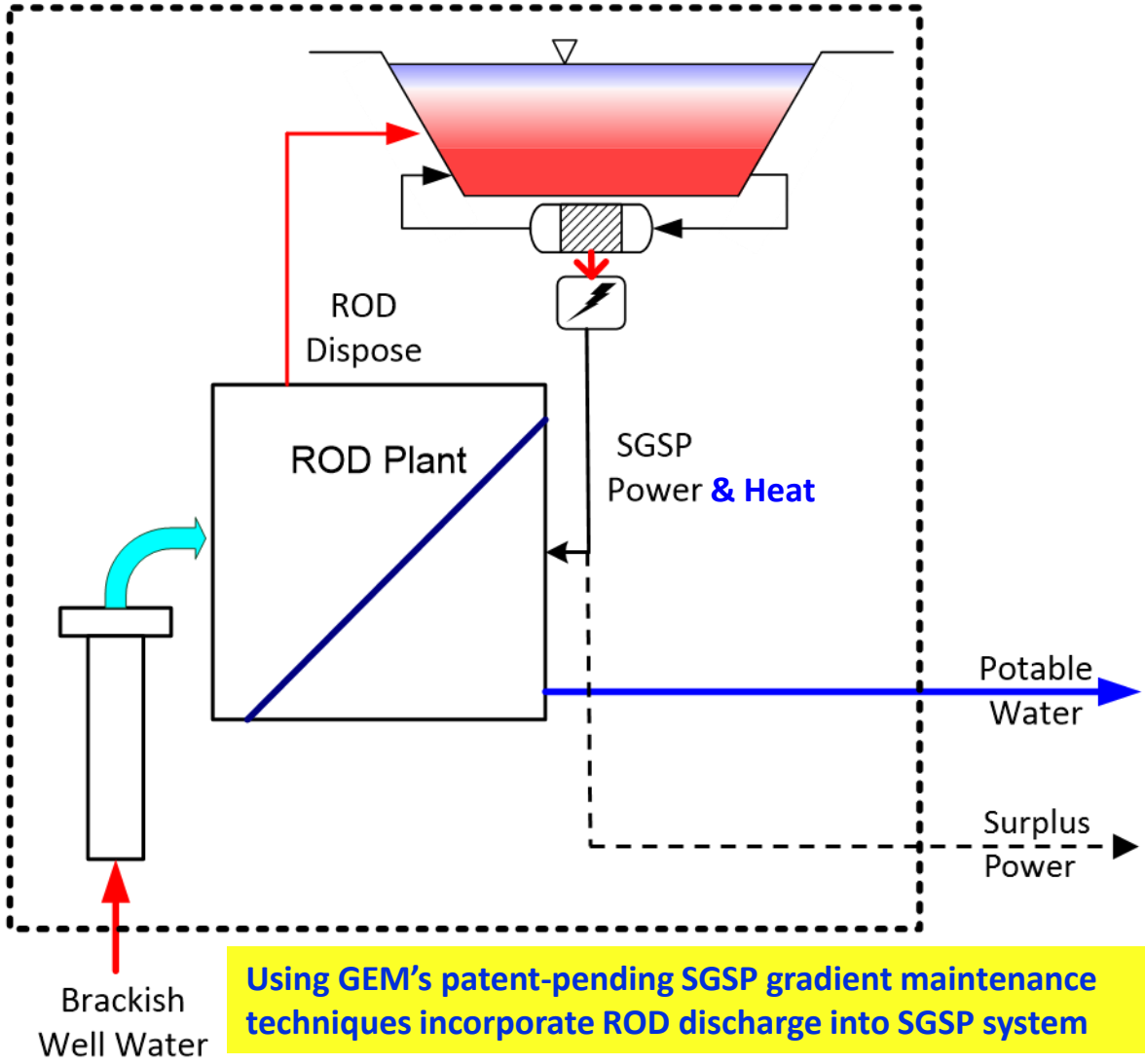
- Regionally deploy SGSP systems to utilize the salt for profitable renewable power production
- Install ~24 MW per year (Red & Brazos River Basins) to match natural inflows, or faster if desired
- Use extraction wells to sequester the salt before it enters the rivers via springs for regional remediation
- Integrate with regional wind-energy to mitigate intermittent inefficiencies
- **Add over 24 jobs/year to the region & over $140M capital development per year**

GEM SGSP – Reverse Osmosis Desalination

Integration for Zero Discharge & Power

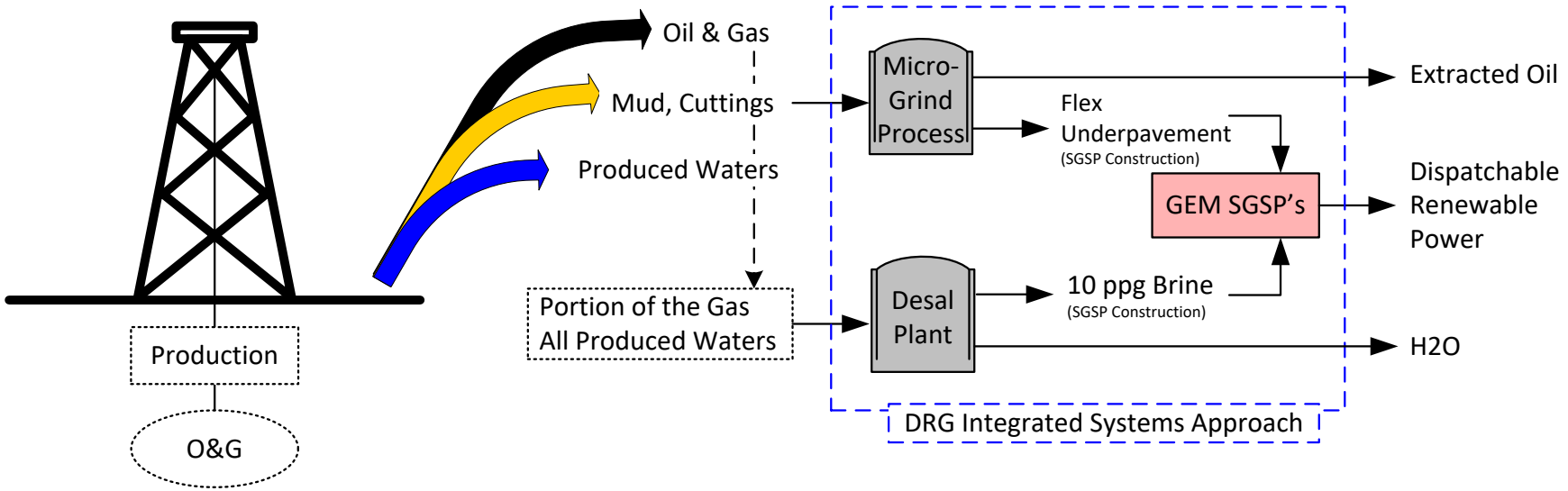
1. Zero discharge
2. Self-powered with cost-effective renewable power
3. Surplus power for ancillary sales
4. Behind the meter, no transmission lines
5. Renewable energy credits

Result: dramatically lower cost water than standard ROD



Using GEM's patent-pending SGSP gradient maintenance techniques incorporate ROD discharge into SGSP system

DRG Integrated Systems Approach:
E&P Waste Recycle / Avoid Induced Seismicity



- **Utilize all E&P waste streams**
- **Negate induced seismicity**
- **Distributed power for E&P**
- **Long-term solution**
- **Representative example →**

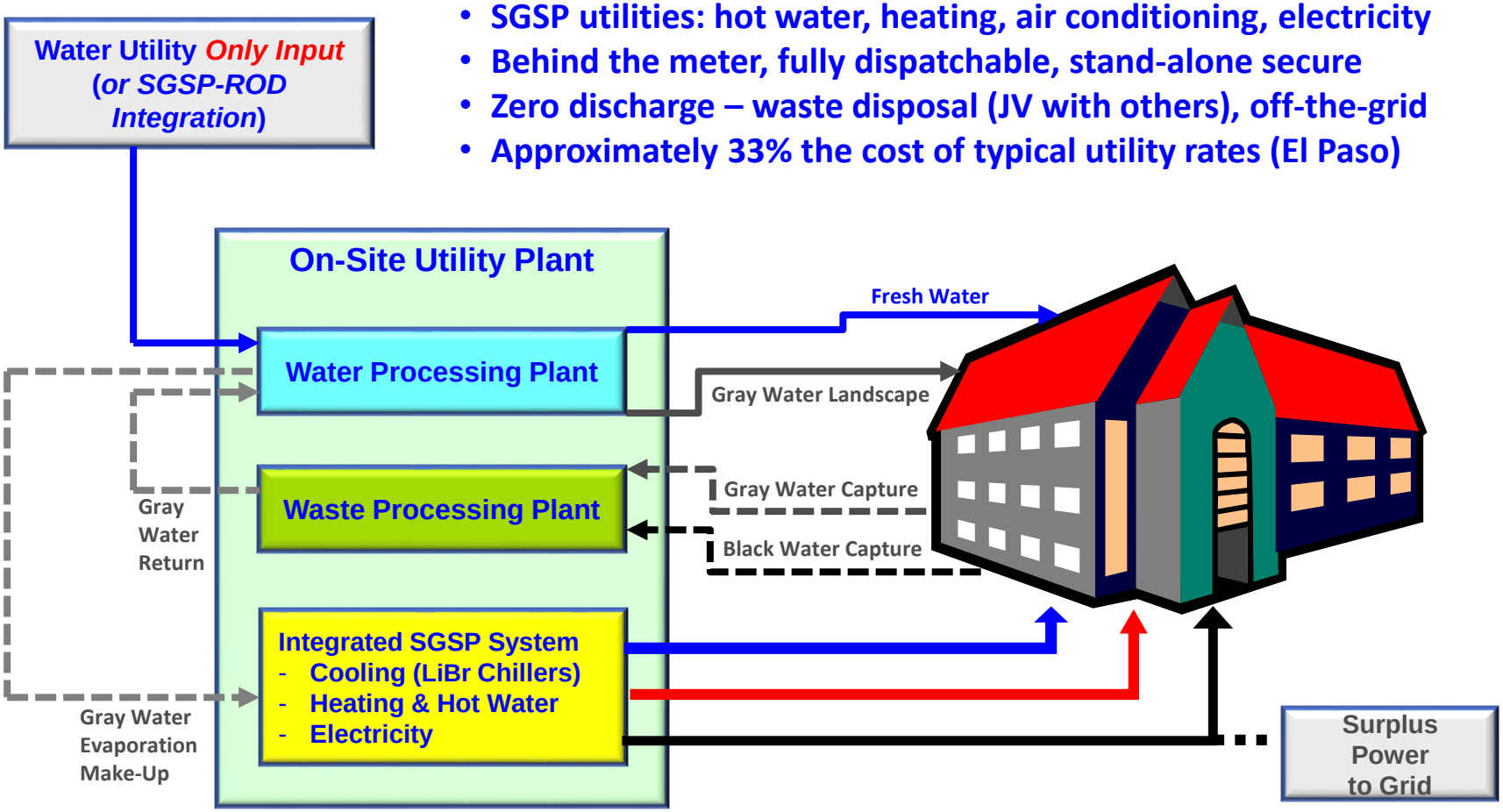
Produced Water Flow Rate	150,000	bpd
Produced Water TDS	120,000	ppm
Concentration Ratio (for 10 ppg brine)	2.49	
Recovered H2O	89,759	bpd
Required Wellhead Gas	3,129	Mcf/day

SGSP MW Build Rate (base-load equiv.)	6.40	MW/yr
SGSP Land Requirement (per MW)	90	acres/MW
SGSP Land Requirement (per yr)	576	acres/yr

GEM SGSP – Off the Grid

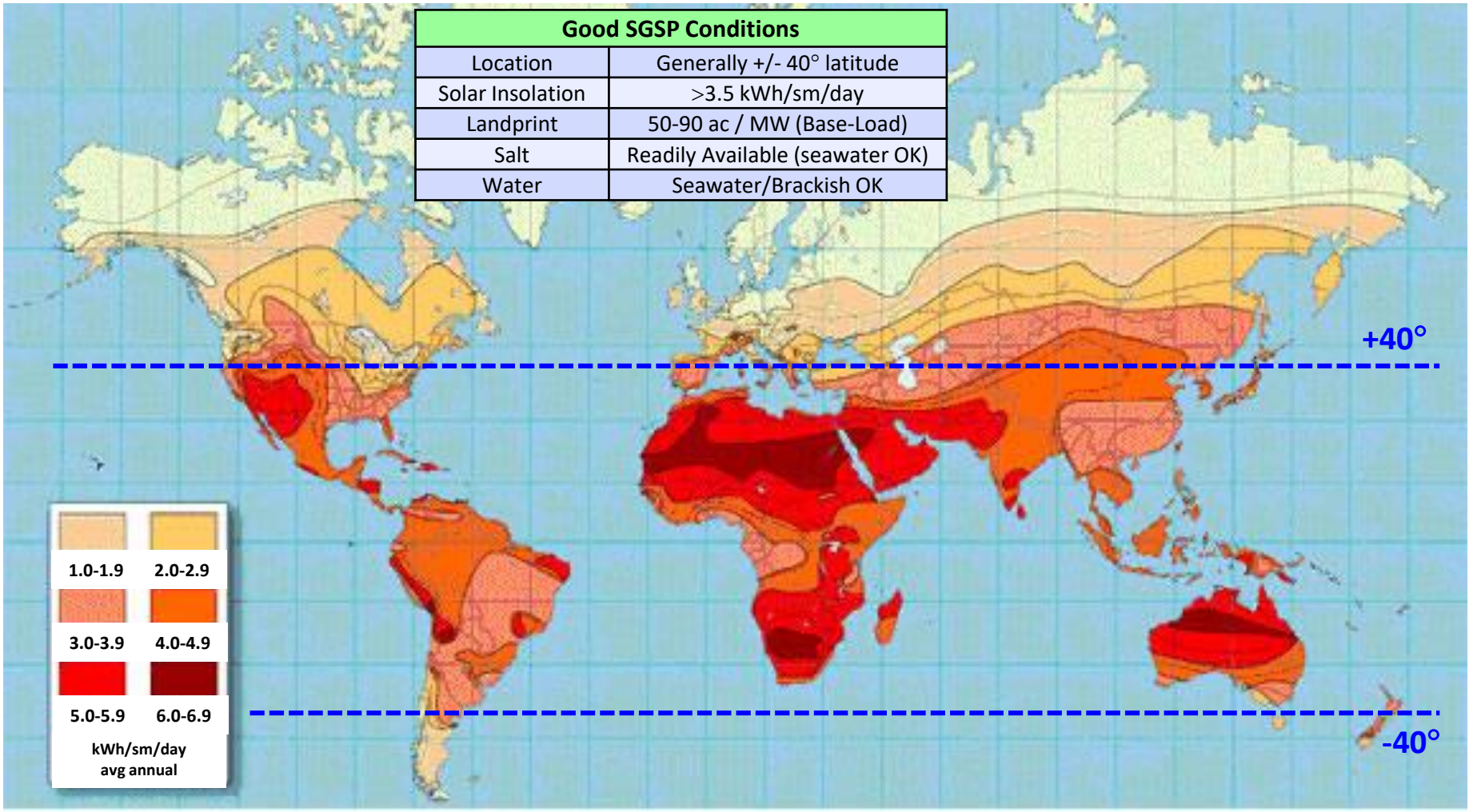
"Net Zero", Secure Base Utilities

- SGSP utilities: hot water, heating, air conditioning, electricity
- Behind the meter, fully dispatchable, stand-alone secure
- Zero discharge – waste disposal (JV with others), off-the-grid
- Approximately 33% the cost of typical utility rates (El Paso)



Large Global Potential for GEM SGSP

Affordable & Secure Renewable Energy & Water



Closing Thoughts / Q&A

- **Total Value Proposition from Truscott SGSP Launch**
  1. USACE RRCCP support & transition to commercial regional chloride control
  2. SAFB renewable and power savings, and other TX USAF bases
  3. Services secure power and utilities – pathfinder, CONUS/OCONUS
  4. Ancillary services by dispatchable renewable for TX ERCOT
  5. Jobs & economic activity for rural America
- **Questions/Comments?**

Thank You!

GEM Team Biographies

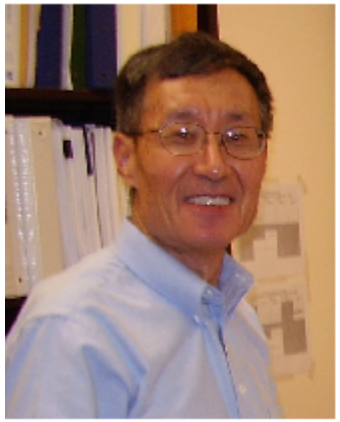
Dr. George S. Nitschke, P.E.
Surface Systems, Renewable Energy

George Nitschke completed his doctorate in Mechanical Engineering, Renewable Energy, at the University of Massachusetts in October 2006. Nitschke received his MSME in 1994 from the University of Washington and his BSME in 1988 from the Wichita State University. In addition to 23 years' experience in the aerospace industry developing air vehicle systems for Boeing and the U.S. Air Force, Nitschke has 12 years' experience drilling exploratory oil, gas, and geothermal wells in Saudi Arabia, Venezuela, Jamaica, Peru, Brazil, Chad, Ascension Island, the Rocky Mountains and the U.S. Midwest. A licensed Professional Engineer, Nitschke holds patents in Geopressured-Geothermal (GPGT) conversion systems and was a principal contributing consultant/author to the U.S. Department of Energy's GPGT consortium (circa 1990-92). Nitschke formed Good Earth Mechanics, LLC in the fall of 2007 to promote the optimal conversion of the GPGT resource into Salinity Gradient Solar Ponds (SGSP) to help solve the U.S. integrated water and energy challenges.

Mr. Peter Gross
Business Development

Peter has over 28 years experience in initiating, developing and managing both the physical and financial aspects of oil and gas operations, natural gas assets, natural gas marketing, and most recently renewable energy concerns. He is recognized as a solid financial and operational executive skilled in both growth and turnaround management situations, and in all phases of business development. Peter's latest focus on renewable energy includes: Geo-Exchange operations: the development of low-temperature geothermal resources in oil and gas fields (sedimentary basins); and of course GEM's GPGT and SGSP technologies.

GEM Team Biographies



Dr. Huanmin Lu
Solar Pond Technology

Huanmin has served as a lecturer and researcher at the Capital Normal University in Beijing, at the Ohio State University in Columbus, and at the University of Texas at El Paso, where he is currently a lecturer in the department of Mechanical Engineering. Huanmin has worked in solar pond research and operations since 1981, and was one of the research principals on the experimental solar pond managed by the University of Texas at El Paso (1989-2002). Huanmin has published 24 papers on solar pond technology, including process heat for anaerobic digestion, dynamic processes of the salinity gradient, instrumentation and monitoring, electric power production, and using solar ponds to manage waste brine of desalination plants. Huanmin also conducted a feasibility study of solar pond technology for the San Joaquin Valley in California.

Mr. Herbert D. Hein, Jr.
Solar Pond Project Management, UTEP

Herb was the key “boots on the ground” guy during nearly the entire UTEP solar pond testing and development phase. Without Herb’s “wizardry” in the field, implementing the theory into practice would have been much more difficult. Herb’s keen field observations and practical insights provided invaluable feedback into the solar pond research and development phase. Herb remains engaged in geophysical R&D field work, e.g., for the DOE and Bureau of Reclamation, and is a sought after asset on such projects.

GEM Team Biographies

Dr. Andrew H. P. Swift, Jr., P.E.
Solar Pond Technology, Renewable Energy Systems

Andy is a Professor and Director of the Wind Science and Engineering Research Center in the Civil Engineering Department at the Texas Tech University, Lubbock, TX. Andy was Dean, College of Engineering, at the University of Texas at El Paso from June 1996 to January 2003, and was a principal investigator on the UTEP experimental solar pond (1985-2002). Andy has published extensively in solar pond research and is a recognized expert worldwide in solar pond technology and experimentation. Andy has served as a consultant and board member to numerous energy concerns. Andy served in the U.S. Air Force (1968-1974, ending rank of Captain), with assignments including: Undergraduate Pilot Training, Reese AFB; Vietnam Service Instructor Pilot; and Assistant Flight Commander. Andy was awarded the Air Medal for his Viet Nam service.

Dr. John C. Walton, P.E.
Solar Pond Technology, Environmental Remediation

John is currently a professor in the Department of Civil Engineering at the University of Texas at El Paso. John was a principal investigator on the UTEP solar pond project, along with Lu and Swift, and co-authored the San Joaquin solar pond feasibility study with Lu. John has worked and published extensively in the areas of nuclear waste, hazardous waste, ground water, alternative energy, and materials degradation. Prior to coming to UTEP John worked primarily in the National Laboratory system in the areas of risk assessment, remediation, and nuclear waste disposal, and has served as an expert witness and advisor to the Departments of Justice and Energy. When not helping to solve the nation's energy and environmental problems, John enjoys the great outdoors with his family (see John's homepage).

GEM Team Biographies

Mr. Dennis Duke
Field Operations, GEM Texas SGSP Projects

Mr. Duke Spent 34 years with Department of Defense, U.S. Army Corps of Engineers (USACE), retired and formed DCS – Duke Construction Solutions. DCS is an owner-operated company doing construction, project management, survey, layout, quality-control, Computer Aided Design, and all field engineering associated work. Dennis' career with the USACE included geotechnical investigation and construction of large embankments, pipelines and pump stations. Dennis served in the construction and operation of the Red River Chloride Control Project (RRCCP) as Construction Engineer and Project Manager (at the Truscott Brine Lake), responsible for the entire operation of RRCCP. Dennis led USACE crews in the repair and modification of large facilities such as Lock and Dams, Hydropower Plants and Embankments and served as Liaison Officer for USACE after hurricanes Rita and Katrina. Dennis developed designs and estimates for all aspects for field construction and repair for USACE in the Tulsa District, including the design and construction for the Civil Works projects in the Tulsa District Corps (contract administration, plan development, construction and modification and project operations). Dennis developed important relationships with partners and stakeholders in developing additional freshwater resources for the Texas - Oklahoma region. Dennis earned a degree from Midwestern State University in Geophysics..

SGSP Reference Engineering & Data

This analysis led to the USBR funding the UTEP SGSP R&D

GEM Proposed SGSP Site	References
U.S. Army Corps of Engineers Truscott Lake, TX	1. Conceptual Design of a 20-Acre Salt Gradient Solar Pond System for Electric Power Production at Truscott, Texas; May, Leboeuf, and Waddington; July 1983 (SERI TR-253-1868) http://nrelpubs.nrel.gov/Webtop/ws/nich/www/bspublic/Record?m=1918 2. Technical and economic feasibility of salt-gradient solar ponds at the Truscott Brine Lake of the Red River Chloride Control Project; Joint Pub. of the Tulsa District, US Army Corps of Engineers and Pacific Northwest Laboratory for the U.S. Dept. of Energy, Sept. 1982 http://www.osti.gov/bridge/product.biblio.jsp?osti_id=6492596
Tooele Army Depot, Hill AFB, Dugway Proving Grounds, UT	3. Functional Conceptual Design Criteria - 5-MWe Salt-Gradient Solar Pond Power Plant at Great Salt Lake; Brown, et al; Pacific NW Laboratory for the U.S. DOE, August 1983 http://www.osti.gov/bridge/purl.cover.jsp?purl=/6012636/ 4. Optimization and Preconceptual Design of a 5 MWe Salt-Gradient Solar Pond Power Plant at Great Salt Lake; Drost, et al; Pacific NW Laboratory for the U.S. DOE, May 1983 http://www.osti.gov/bridge/product.biblio.jsp?osti_id=6274180
White Sands Missile Range, NM	5. Southwest Region Solar Pond Study for Three Sites: Tularosa Basin, Malaga Bend, and Canadian River; Boegli, Dahl, and Remmers; Bureau of Reclamation, Denver, CO Engineering Research Center, May 1983 http://www.ntis.gov/search/product.aspx?ABBR=PB85186211
Salton Sea, CA (civil, potential military)	6. Salton Sea Project, Phase 1 Final Report; M.L. Peelgren; Prepared for the U S Department of Energy Through an Agreement with National Aeronautics and Space Administration by the Jet Propulsion Laboratory, California Institute of Technology (JPL PUBLICATION 81-108); Jan.15, 1982 http://www.ntis.gov/search/product.aspx?ABBR=DE82009131
Other Applicable References	7. Advancements in Salinity Gradient Solar Pond Technology Based on 16 Years of Operational Experience, Lu, Swift, Hein, and Walton; J. Solar Energy Eng., v.126, p. 759-767, May 2004 http://www.goodearthmechanics.com/pdfs/JSEE%20Paper%20Lu%20SP.pdf 8. The Beith Ha'Arava 5 MW(e) Solar Pond Power Plant (SPPP) - Progress Report; Tabor and Doron; Solar Energy, Vol. 45:4, January 1990 http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=6193732

Nearly all GEM proposed SGSP sites have been approved/endorsed by Govt. analysis

Example SGSP Past Experiences

SGSP Project	Size	Operational Dates	Objectives	Decommission Notes
Salta University, Argentina	16 sq.m	c.1977	test pond: space heat, sodium sulfate refining	1
Miamisburg, OH	0.50 acre	1978 – 1990	heating for swimming pool: 281,000 kWt-hr/yr (annual average 16 Wt/sq.m)	2
Palestine West Bank Beith Ha'Arava	9.88 acres 51.9 acres	1984 – 1989	SGSP development: two-step project for electricity generation (1.25 MWe rated)	3
Univ. of Texas El Paso	**0.83 acre**	**1985 – 2002**	**SGSP development: electricity generation, desalination & brine management**	**4**
Australia (Alice Springs)	0.40 acre	1985 – 1989	20 kW ORC electricity gen. (peak)	5
Los Banos, CA	0.5 acre	1985 – 1989	electricity generation 10 kW ORC	6
Margheria di Savoia, Italy	6.18 acres	c.1991	desalination, 500 kWt (32 kgal/day)	7
RMIT Univ., Geo-Eng & Pyramid; Australia	0.74 acre	2000 – 2010	heat for commercial salt production; 60 kWt continuous (20 Wt/sq.m average)	8
Bhuj SGSP Project, India	1.5 acres	1993 – 2000	process heat for a dairy, pre-heat boiler feed water, cleaning and washing	9

Decommission Notes

1. Unknown, suspect it was a small-scale, project-specific University investigation and the research ended.
2. Miamisburg staff understands the heat-pond was discontinued in 1990 because the contractor used the wrong solder on the pipes, which caused the pipes to eventually leak making the pond ineffective.
3. The reason for decommissioning was geopolitical (i.e., land turned over to Palestinians), rather than performance related (Akbarzadeh, Andrews and Golding, 2005).
4. **Bureau of Reclamation decommissioned the SGSP site in 2002, determining that the UTEP team had successfully gleaned all that could be learned from the project.**
5. SGSP demonstration and PhD research supported by the Northern Territory Government and the National Energy Research, Development and Demonstration Program (Australia) – R&D project ended.
6. Project ended when agricultural drain water supply was discontinued due to high selenium content discovered in the water, leading to bird deformities (Kesterson Reservoir / Wildlife Refuge).
7. Unknown
8. The Pyramid Hill project was set up for research (government grant) and later the Pyramid Hill salt company continued operation (10 yrs) to supply hot water for its 'flash drying' salt operation; it's believed Pyramid stopped the project as they valued the pond's salt more than the energy offset by the pond.
9. Severe financial losses to the parent company (Kutch Dairy) and the Bhuj earthquake closed the pond in 2000